

# **EXHIBIT “F”**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: )  
RODNEY M. LAFOLLETTE, ET AL. ) Docket: 7310  
Serial No.: 09/037,801 ) Art Unit: 1745  
Filed: March 10, 1998 ) Examiner: R. ALEJANDRO  
For: MICROSCOPIC BATTERIES FOR MEMS ) S. KALAFUT  
SYSTEMS )  
)

**THIRD DECLARATION OF RODNEY M. LAFOLLETTE, PH.D.**

Honorable Commissioner of Patents and Trademarks  
Washington, D.C. 20231

Sir:

I, Rodney M. LaFollette, state as follows:

1. I am a citizen of the United States of America and a resident of the State of Utah.
2. I have earned a Doctorate in Chemical Engineering from the Brigham Young University.
3. My educational and professional resume is of record, being attached as Exhibit "A" to my first Declaration.
4. I have over 12 years of business and educational experience. This experience includes extensive experience in the electric battery field, and particularly in making battery inventions and commercially developing the same.
5. I am an inventor, either sole or joint, of inventions comprising the subject matter of U.S. patent applications and issued patents. I am a co-inventor of the invention of the above-identified patent application.

6. I have worked extensively in research and development pertaining to electric batteries and am thoroughly familiar with various electric battery, fuel cell and capacitor developments and that which is required for each to be operational.

7. I have been requested to provide an assessment of the Office Action mailed October 20, 2000, of the claimed subject matter of the above-identified application in comparison with a certain prior art patent, to provide information concerning the clarity of certain language within the presently pending claims and to address the new matter issue raised by the Examiner in the Office Action.

8. I consider my skill in the electric battery field to be above ordinary skill.

9. In the course of functioning as indicated above, I received and studied a copy of the above-identified application, as filed.

10. I received also a copy of the Office Action in the above-identified application mailed October 20, 2000, and a copy of the patent relied upon by the Examiner in said Office Action.

11. I was asked to evaluate the 35 USC § 112, first paragraph, the 35 USC § 103(a) rejection contained within the Office Action and Examiner's Response to Arguments.

12. I am familiar with the invention of the above-mentioned application, as originally filed, and the claims as originally filed and as presently constituted, because I have studied both. I have also read and studied the patent relied upon in the said Office Action and the latest Office Action.

13. The Examiner at paragraphs 1 and 3 of the Office Action contends that the limitations "range of about  $10^{-0.4}$  to about  $10^{1.6}$  KW/kg and specific energy within the range of about  $10^{1.1}$  to

about 10<sup>2.1</sup> kJ/kg" constitutes now matter under 35 USC § 132 and § 112, first paragraph. Figure 17 provides the disclosure required for the substance of Claim 109.

14. Elected claims 10-43, 51-54, 89-92, 94-97 and 103-109 were rejected under 35 USC § 103(a) as being unpatentable over Arledge et al. (U.S. 5,437,941, sometimes the '941 patent and sometimes Arledge or Arledge et al.).

15. By way of background, Arledge et al. disclose an "electrical energy storage device," using ultra thin-film techniques. Arledge et al. confine their invention "more particularly to capacitors or electrochemical cells. The '941 patent erroneously states that "both capacitors and batteries store energy by the separation of positive and negative charges," incorrectly suggesting that the '941 invention includes both batteries and capacitors. They present the need for energy storage devices that"can store much larger amounts of energy in a smaller package." They inaccurately purport their invention to be a "small energy storage device with a capability to store large amounts of electrical energy." Finally, they overly simplistically imply that "while the behavior . . . is capacitive in nature, by employing different electrode materials, an electrochemical cell such as a battery can be created." They mention various metal oxides as potential electrode materials, which allegedly could provide both capacitive and battery types of behavior; i.e. "pseudocapacitive" behavior.

16. The invention of Arledge et al. is wholly confined to ultra thin-film capacitors, despite their assertions to the contrary. Further, the Arledge et al. disclosed technology could not be used to make a practical or useful microscopic battery integratable with a microcircuit. Finally, the present invention; which combines the ability to make very small area cells with film components, the thickness of which is significantly greater than Arledge, represents an important

contribution to microscopic energy storage technology, distinct and nonobvious from Arledge et al.

17. Arledge et al. incorrectly state, as a premise, that both batteries and capacitors store energy by separating positive and negative charges. This is true of capacitors; it is not true of batteries. Batteries store their energy, not by separation of charge, but rather in the *chemical bonds* of the reactants used in the battery. The actual reactants in a battery may actually be in close proximity, even in physical contact. However, the energy in a battery is not released, unless an actual chemical reaction occurs, converting the *chemical energy* of the reactants into *electrical* energy. Thus, the stored energy in a capacitor has everything to do with electrostatic charge separation, and nothing to do with chemical state. The reverse is true of a battery. The flawed premise of Arledge et al. belies the direction of their invention, and helps us understand why their assertion that their capacitor development is transposable to batteries is false.

18. Arledge et al. summarize their technology as the result of using thin-film techniques to make cell components, such as electrodes. They characterize thin-film as typically being < 10000 Å. Example processes include sputtering and various evaporation techniques.

19. In a capacitor, charge is stored on the surface of a material, such as a foil, or high surface area metal oxide. Thus, in capacitors, a large electrode surface area is of primary importance; the unexposed interior mass of the electrode does not contribute to the amount of energy that can be stored. Therefore, the thinner the capacitor electrode the better. Capacitor electrodes add to the weight, and for this reason, ultra thin electrode materials are often used in capacitors to maximize the surface area, while minimizing the electrode mass. The “thin-film” technology described by Arledge et al. are applicable for making capacitor electrodes, which need to maximize the ratio of surface area to volume. They are not applicable to the manufacture of batteries.

20. With batteries, the amount of energy that is effectively stored is proportional to the *mass* or volume of the electrode, and its surface area is of only secondary importance. The thinner a battery electrode becomes, per unit area, the less energy that it contains. Thus, everything else being equal, a battery electrode, optimized for high energy storage, will be thicker, not thinner.

21. Arledge et al. discloses the use of ultra thin-film process for making capacitors. The ultra thin electrodes of Arledge could not and would not be effective for making useful batteries. This is related to the fact that such processes are limited to typical thickness of < 1  $\mu\text{m}$ . Efforts to make thicker material layers, with ultra thin-film processes, have never been successfully used to make a battery.

22. Arledge et al. does not use standard thin-film processes to make the one element of their capacitor with an appreciable thickness, namely, the separator between the electrodes. Small glass beads are dispersed in a liquid. The resultant slurry is then spin-coated over the electrode surface. While spin-coating is commonly used in microelectronics, for example to apply photoresist layers, it is not considered a thin-film process per se.

23. To illustrate the relative differences between the capacitors of Arledge et al., and microscopic batteries according to the present invention, we can compare the energy storage per unit cell area ( $\text{J}/\text{cm}^2$ )<sup>7</sup>. The highest value for the capacitors of Arledge et al. is 0.005  $\text{J}/\text{cm}^2$ . Microscopic batteries of the present invention are 2 - 20  $\text{J}/\text{cm}^2$ . Thus, the present invention has energy storage values 4000 times higher than an Arledge capacitor. Therefore, Arledge et al. fail in their attempt to create a "small energy storage device with a capability to store large amounts of electrical energy." Their device is not small when compared to the present invention; nor does it store large amounts of energy.

24. The considerable value of the present microscopic battery technology, over any cell comprising the ultra thin-film electrodes of Arledge, is apparent to microelectronics fabricators. Simply stated, more energy can be stored in a smaller area on a chip. For example, the capacitor of Arledge et al. would need to occupy roughly 1000 times the area of a battery of the present invention to store the same energy. I have done extensive study of the energy and power needs of MEMS and other microelectronics. I know the range of energy storage capabilities that small devices will need. The present invention accommodates the making of batteries as part of an integrated microelectronic circuit, which batteries are comparable in size to the other device components. The capacitor of Arledge et al. can not do this. The size of the Arledge capacitor would be incompatible with integration thereof into a MEMS.

25. The ultra thin-film electrodes of Arledge work in capacitors. They are not useful for making operable battery electrodes, due to the limited energy storage capabilities of such ultra-thin layers.

26. In further support of the position that the Arledge et al. disclosure is limited to capacitor in their proposed list of electrode materials, various metal oxides are listed, such as those of ruthenium, tantalum, rhodium, iridium, cobalt, nickel, molybdenum, tungsten, and vanadium. They state that these materials not only have high surface areas (needed in capacitors), but that they also exhibit "pseudocapacitance," which means to an artisan that they also undergo chemical reactions during capacitor operation, which supplement the overall electrical discharge. The metal oxides they mentioned are almost universally considered capacitor electrode materials, rather than those that would be useful in batteries. Nickel, cobalt and vanadium are exceptions. However, it is apparent from the context of the discussion in Arledge et al. that the presence of these oxides in

their list of candidate materials is based on their capacitive behavior, rather than any utility as chemical reactants in a battery. Further, long experience has shown that electrode materials that work well in capacitors rarely if ever are useful battery materials.

27. The standard ultra thin-film electrodes of Arledge et al., are not per se useful as battery-grade electrode materials. This is particularly true of cathode materials, such as metal oxides. For a material to be electrochemically active, and, therefore, useful in a battery, it must not only have the desired overall chemical composition, but it must also have the right crystal structure. For example, lead dioxide ( $PbO_2$ ), the active material in the positive electrodes of lead acid batteries, is not useful, unless it has the proper crystal structure. The various intercalation materials used in lithium-ion cathodes do not work, unless they are of a certain structure.

28. Simply sputtering a metal oxide, such as nickel oxide, onto a glass substrate, may result in a high surface area layer which is useful for capacitors, but it will not result in a useful battery electrode material.

29. To further illustrate the fact that the Arledge et al. disclosure does not pertain to batteries, note both examples cited in Arledge et al. describe two electrodes, made using tungsten metal. An electrolyte, such as sulfuric acid, perchloric acid, sodium carbonate, or potassium hydroxide is then added to the cell. Arledge et al. then state that the observed behavior is "analogous to a capacitor." Figure 4 is shown as an example of the voltammetry of one such cell. The fact that the behavior does not show any "battery"-type behavior is conclusive. There is a complete absence of any faradaic (battery) behavior in the data presented by Arledge. Thus, the tungsten metal that they deposited, using their ultra thin-film techniques, is not active battery materials.

30. There are two issues, related to fabrication, which are further reasons that Arledge et al. cannot be used to make microscopic batteries as disclosed in the present application. The first has to do with miniaturization; the second with integrability.

31. Arledge et al. do not describe any mechanism or method for making microscopic (small area) structures, a requirement of the present invention. Their examples describe only capacitors, the cross-sectional areas of which are large, non-microscopic and not integratable with microelectronic circuits (i.e.  $20\text{ cm}^2$ ). Ultra-thin electrodes are used, but macroscopic techniques are employed for cell assembly functions, such as sealing the cell with epoxy.

32. The Arledge technology would never work to make very small footprint battery cells, a requirement of the present invention.

33. Small footprint energy storage components are needed for the present invention, which have relatively high capacity per area ( $\text{C/cm}^2$ ). Cells according to the present invention are so small that they are almost invisible to the naked eye. There is absolutely no way that the invention of Arledge et al. provides for this possibility.

34. Perhaps the greatest contribution of our invention is its integrability, i.e. batteries can be made, not only as discrete components, to be attached to an existing microcircuit, but also as a fundamental part of the entire microcircuit. Arledge et al. does not disclose such an important contribution, nor is such possible with Arledge et al. Batteries can be small enough so that their footprint on a chip is compatible in size to the rest of a microelectronic circuit.

35. The processes of Arledge et al. will not result in useful battery materials.

36. The assertion that the present microscopic battery invention is obvious to skilled in the art from Arledge et al. is erroneous. If such were so the Arledge et al. capacitor technology would have been transposed to microscopic battery technology long ago. It has not been.

37. In conclusion, Arledge et al. cannot be used to make microscopic batteries according to the present invention. Furthermore, there is no obvious way to extend Arledge et al. to include batteries, much less microscopic batteries. Some of the reasons for this are:

- a.. The devices of Arledge et al. exhibit only capacitive behavior, and do not show any battery behavior.
- b.. The thin-film technology described by Arledge et al. cannot be used to make useful battery materials, due to limits in thickness and chemical structure.
- c.. Cells made by Arledge et al. are very limited in the amount of energy that can be stored in a given area ( $J/cm^2$ ).
- d.. Arledge et al. does not provide for the microscopicization of cells. Arledge et al. provides ultra thin large area (huge footprint) structures, not those with a small area or footprint.
- e.. Arledge et al. does not and cannot permit true integration of energy storage into integrated microcircuits.

38. I hereby declare that all statements made herein are of my own knowledge to be true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under § 1001 of Title 18 of the United States Code and

that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

DATED this 15 day of December, 2000.

Rodney LaFollette  
RODNEY M. LAFOLLETTE, PH.D.

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